ON THE USE OF MEASUREMENT AND CLIMATIC DATA FOR AIR POLLUTION IMPACT ASSESSMENT

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INTRODUCTION

The model estimate of the mean and extreme levels of air pollution near different working or future industrial enterprises is a very important element of the total environmental impact assessment. According to the short-term approach, one-year period is used, meteorological measurements done every hour. It is clear that data from automatic meteorological stations must be used for the purpose. In many East-European countries, however, the wind measurements are still made using the out-of-date Wild anemometers and the time resolution of the observations is quite low (1, 3 or maximum 8 times a day). From the other side, if even available, the data from the few automatic stations often can not be expanded to distant locations because of the complex orography. In spite of the many disadvantages, the Wild anemometer data contain useful information and very often is the only available information about the meteorological regime in many regions. Lots of climatic calculations are made over such data, results published in the open specialized literature as *Kuchukova M.* <ed.>, 1983-1990. Such climatic reference books often are the only source of information on the meteorological regime of many regions. In the paper the use of climatic data is examined versus the usual way of case by case model calculations (long-term calculations vs. short-term ones).

MODELS AND DATA

In the paper, three different types Gaussian models are used for calculation of surface concentration and total deposition fields of some atmospheric pollutants. Those are Gaussian-type models used for environmental impact assessment. Description of the models can be fined in *Doncheva et al.* (1993), *Ivancheva et al.* (1998) and *Syrakov et al.* (1998). Models mainly differ in the meteorological input requirements.

- GAS_E и AER_E models use as meteorological input hourly data for temperature, wind direction and speed, precipitation intensity and the Pasquill atmospheric stability class;
- GAS_R и AER_R models use as meteorological input a two-component wind rose (direction-velocity), an expertly determined atmospheric stability class, precipitation amount and its duration for the studied period.
- GAS_Rnew и AER_Rnew models use as meteorological input the three-component wind rose, representing wind velocity and direction distribution for different Pasquill classes and the mean precipitation intensity for every class (or precipitation amount and the number of rainy hours).

The above models allow numerical simulation of the possible mean annual pollution with long-living aerosols (LLA), which would follow the operation of a reactor block of 1000 MW power, analogous to the Block V reactor of NPP "Kozloduy", at the average operation mode for the period 1994-1998. Calculations are made for a 60×60 km region around NPP "Belene" project site in an uniform grid with 1 km step; for each gridpoint the mean annual concentrations of LLA (in [$\mu Bq/m^3$]) or average for the year diurnal deposition of LLA (in [$\mu Bq/m^2$]) are calculated. Source features are: coordinates X = 32 km, Y = 26 km; stack height H = 150 m; stack aperture d = 3 m; gas ejection velocity V_{gas} = 15 m/sec; gas temperature t_{gas} = 40°C and annual emission of LLA = 1055 MBq.

Hourly data from an automatic meteorological station situated at a representative for the region location have been used for meteorological input to GAS_E and AER_E models. The results of their performance (Figure 1 and 2) are accepted as bases and all remaining calculation results are compared with them. For the sake of convenience the concentrations and depositions obtained by GAS_E and AER_E models are further called “reference” fields.

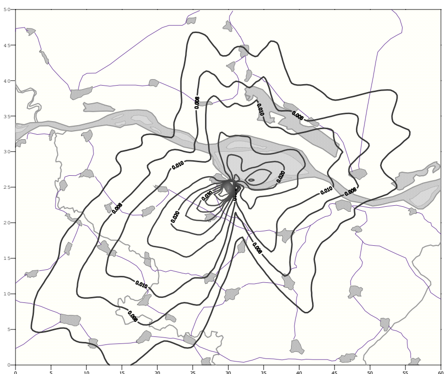

Figure 1. The year average concentration field of LLA [μBq/m^3] – *2001.*

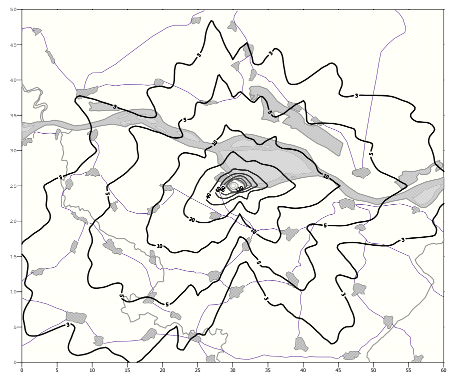

Figure2 . The year diurnal depositiin field of LLA [μBq/m^2] – *2001.*

The same data is used to calculate 3- and 2-component wind roses together with the respective precipitation characteristics. Finally, a rough 2-component rose is determined with the classes used in Bulgarian climatic reference book [*Kuchukova M.* <ed.>, 1983-1990]. Statistical methods have been used to compare different model results.

COMPARISON OF GAS_E AND AER_E WITH GAS_RNEW & AER_RNEW MODEL RESULTS

Table 1 shows the comparison of the reference results and mean annual fields obtained by using the 3-componend rose as meteorological input. In the Table, C01 и D01 are the reference concentrations and depositions while C2 и D2 denote the corresponding fields obtained by GAS_Rnew and AER_Rnew.

Table 1. Pollution fields statistics (GAS_E/AER_E vs. GAS_Rnew/AER_Rnew).

Variables	Average	St. deviation	St. error	Maximum	Correl. Coef.
C01	0.011	0.0051	0.00016	0.0555	0.96
C2	0.011	0.0056	0.00017	0.0565	
D01	5.14	7.54	0.135	165.0	0.97
D2	1.91	1.91	0.034	40.2	

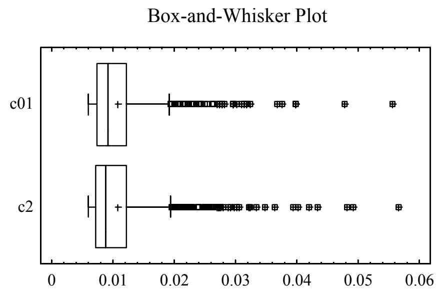

Figure 3. Comparison of concentrations.

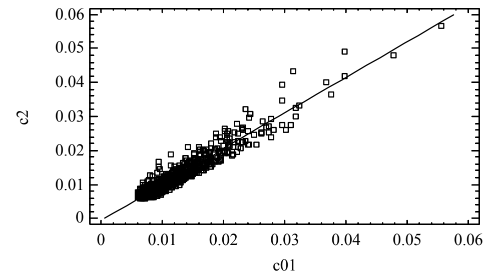

Figure 4. Scatter diagram of C01 and C2.

The scatter diagram and the Box and Whisker plot indicate that concentration fields obtained by the two different models are almost identical. Since the interval contains the value 0.0, there is not any statistically significant difference between the means and standard deviations of the two samples at the 95.0% confidence level. The correlation coefficient equals 0.96 that indicates strong relationship between the fields. This analysis shows that in case of availability of 3-component rose (direction-velocity roses for every stability class) the mean l concentration field calculated by AER_Rnew and GAS_Rnew models possesses a high degree of reliability.

Table 1 and Figure 5 and 6 show that in spite of the high correlation between the two deposition fields, there is a significant difference in the remaining statistical characteristics. The mapping of the deposition fields obtained by two methods shows almost identical geometry but different values. The reason for this diversity is the random way of forming of the wet deposition in both short-term and long-term models. When using AER_E and GAS_E the wet deposition is switched on only few times and takes the form of the particular plume. In the climatic calculations the wet deposition acting permanently, respective field accumulated with the respective weight. So, the use of climatic models gives a qualitative, yet insufficient quantitative representation of total deposition field.

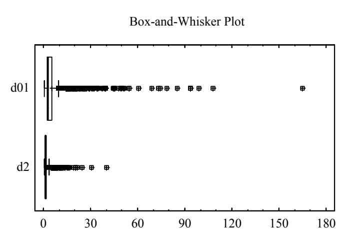

Figure 5. Comparison of mean depositions.

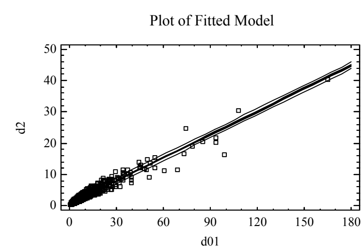

Figure 6. Scatter diagram of D01 and D2.

COMPARISON OF GAS_E AND AER_E GAS_R AND GAS_R AND AER_R MODEL RESULTS

In this case only 2-component wind rose is available as meteorological input. The mean precipitation intensity is determined as the ration between the precipitation amount and the whole duration of rain events. As far the stability class is also input to GAS_E and AER_E, its mean value is not known in advance. It must be determined as the best fit to the reference fields performing calculations with all possible classes.

The comparison is carried out in two steps:

Wind rose with high resolution. The use of high frequency and high resolution row data from the automatic meteorological station allows to calculate more precise rose with 16 directions and 8 velocity intervals (0-0,5 m/s; 0,6-1,0 m/s; 1,1-1,8 m/s; 1,9-3,0 m/s; 3,1-5,0 m/s; 5,1-8,0 m/s; >8m/s).

The major statistical characteristics of concentration (C2i) and deposition (D2i) fields, obtained for different stability classes (i = a, b, c, d, e) are shown in Table 2. As seen from Table 2, closest to reference concentrations are those obtained under the assumption that during the year the atmosphere is on average in neutral equilibrium (class D by Pasquill classification). The correlation coefficient equals 0.85 indicating a moderately strong relationship between C01 and C2d. This naturally follows the fact that the frequency of this class has been the highest in the course of the year. The good approximation of this stability class is illustrated in Fig. 7 and 8. Results show that the appropriate use of GAS_R model describes with sufficient accuracy 73% of mean annual concentration field of LLA for the year 2001

Table 2. Determination of the mean stability class (GAS_E/AER_E vs. GAS_R/AER_R).

Variables	Average	St. deviation	St. error	Maximum	Correl. Coef.
C01	0.011	0.0051	0.00016	0.0555	
C2a	0,021	0,034	0,0015	0,32	0.53
C2b	0.020	0.026	0.0009	0.20	0.64
C2c	0.018	0.018	0.0004	0.15	0.79
C2cd	0.019	0.014	0.0003	0.098	0.80
C2d	0.018	0.007	0.0002	0.05	0.85
C2e	0.010	0.003	0.0001	0.02	0.65
D01	5.14	7.54	0.135	165.0	
D2d	3.59	3.29	0.005	72.8	0.94

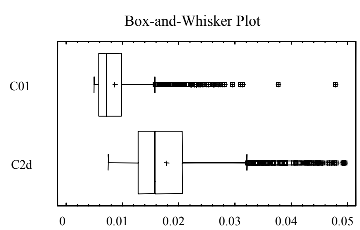

Figure 7. Two-component wind rose, class D - comparison of concentrations.

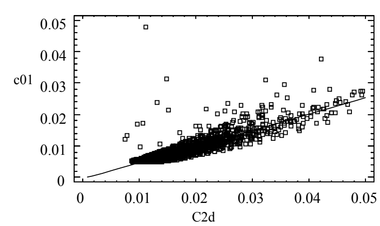

Figure 8. Two-component wind rose, class D – scatter diagram for concentrations.

The analysis of the unusual residuals shows that the greatest discrepancy between the two fields lies in the region of the field maximum and along the northeastern and southwestern border of the considered area at 30 km from the source, which makes the results entirely acceptable.

As regards LLA deposition, the use of stability class D gives again the best agreement. The correlation coefficient equals 0.94, indicating a relatively strong relationship between the variables. The R-Squared statistic indicates that 87.6% of the variability in D01 can be explained by D2d.

Figure 9. Two-component wind rose, class D - comparison of depositions.

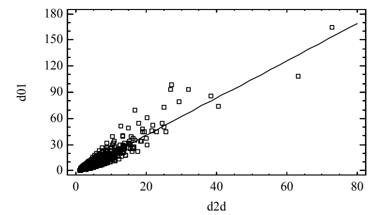

Figure 10. Two-component wind rose, class D – scatter diagram for depositions.

Wind rose with low resolution. Here the precise data is used to produce a wind rose similar to those calculated from Wild anemometer data and published in the Bulgarian climatic reference book (*Kuchukova M.* <ed.>, 1983-1990). These kinds of roses are with 8 directions and 3 velocity intervals (1.0-0.5 m/s; 5.1-8,0 m/s; >8m/s). As the prevailing part of the Bulgarian meteorological network is equipped with Wild type anemometers, the existing wind regime information is based on such type of roses. That is why it is important to estimate the reliability of the pollution fields calculated by using such a meteorological input. GAS_R/AER_R models are fed in with the simplified wind rose, results shown in Table 3.

Table 3. Low Resolution wind rose - Comparison statistics.

Variables	Average	St. deviation	St. error	Maximum	Correl. Coef.
C01	0.011	0.0051	0.00016	0.0555	0.72
C2k_d	0.018	0.0126	0.0003	0.088	
D01	5.14	7.54	0.135	165.0	0.93
D2k_d	4.57	3.77	0.081	47.9	

According to the displayed statistical characteristics, even when a coarsest wind rose is used, application of GAS_R and AER_R models combined with an appropriately chosen stability class (D in this particular case) allows a qualitative assessment of concentration and deposition fields. Discrepancies in concentration values are primarily concentrated in the zone of maximum values, so we can claim a good qualitative assessment over the greater part of the field.

CONCLUSION

Comparison of results obtained by simulation of mean annual concentration and deposition fields using different Plume type model versions allows to draw following conclusions:

- The results obtained by GAS_Rnew and AER_Rnew models show best approximation of the adopted reference results (obtained by the short-term model GAS_E/AER_E). However, such calculations may be carried out only in cases, when sufficiently representative and detailed meteorological information allowing calculation of three-component wind rose is available.
- The use of two-component wind rose combined with expertly determined atmospheric stability class allows a very good assessment of the pollutants concentration field and a qualitative assessment of the deposition field.
- The use of the GAS_R/AER_R models fed with the meteorological information from the Bulgarian climatic reference books gives relevantly useful estimates for use in environmental impact assessment of the influence of different industrial sources on the air quality.

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